## REMARKS

A Request for Continued Examination has been submitted concurrently herewith, together with the appropriate fee therefor. Accordingly, further examination of this application based on the foregoing amendments, as well as the matters discussed hereinafter, is respectfully requested.

In response to the Examiner's comments in the Continuation Sheet attached to the Advisory Action dated November 6, 2007, concerning the substitute specification submitted October 29, 2007, Applicants have requested that the blank page of the original application which follows Claim 14 and bears the number -18- be deleted, and that the page originally numbered -19- be renumbered as page -18-. Applicants have also affirmed that this application as filed contained, and was intended to contain, only 14 claims, that the blank page originally numbered -18- was included through an oversight, and that the application as filed was complete, no portion thereof having been omitted. Accordingly, the submission of a substitute specification is believed to be unnecessary.

Claims 1-3 and 5-14 are currently pending in this application. Claims 1, 3, 10 and 11 have been rejected under 35 U.S.C. §102(a) / 102(e) as being anticipated by Autenrieth et al (European patent document EP 1 205 341 A2) which is the counterpart of Published U.S. Patent Application No. 2002/0057006 A1. In addition, Claim 2 has been rejected under 35 U.S.C. §103(a) as

unpatentable over Autenrieth et al, while Claims 6-9 and 12-14 have been rejected as unpatentable over Autenrieth et al in view of Higashiyama et al (U.S. Patent No. 6,890,673) or Leboe (Published U.S. Patent Application No. 2004/0080297). Finally, Claim 5 has been rejected as unpatentable over Autenrieth et al in view of Merritt et al (U.S. Patent No. 5,366,821). However, for the reasons set forth hereinafter, Applicants respectfully submit that all claims which remain of record in this application distinguish over the cited references, whether considered separately or in combination.

The present invention is directed to a method for controlling the operation of a fuel cell system, and in particular for controlling the supply of fuel to the anode side of a fuel cell system, in a manner which optimizes the system response to dynamic changes in demand for output power. As is well known to those skilled in the art, the dynamic response of fuel cell systems frequently lags the power demand of the load to which the fuel cell system is connected. For this reason, an energy storage device, such as a battery is commonly connected in parallel with the fuel cell system in order to make up for shortfall of available power output from the fuel cell system. As is also well known to those skilled in the art, the output capacity of a fuel cell system is directly dependent on the amount of fuel which is currently available in the anode.

One problem with fuel cell systems is that in the face of a sharp increase of demand for power output, damage to the fuel cell can result from an overload

condition if no action is taken. Accordingly, one approach to remedying this situation, which is illustrated by Autenrieth et al, is to switch the connection between the fuel cell and the load off and on in order to reduce the overall power output of the fuel cell during overload periods.

The Autenrieth et al reference is therefore an example of the method defined in the preamble to Claim 1 of the present application. Its operation is described in paragraph [0016] at lines 6 through 13; paragraph [0021] and paragraph [0029]. For example, as described in the specification at paragraph [0021], the fuel cell unit 3 is electrically switched off if the load requirement exceeds the amount of fuel that is currently available to the fuel cell. <u>While the fuel cell unit is switched off, fuel and/or oxygen continue to be supplied at the same rate as before</u>, and accumulate in the system because they are not consumed by the fuel cell (being switched off). This mode continues until a sufficient quantity of fuel and/or oxygen has become available for the fuel cell to be able to provide the required electric power. (See, for example, paragraph [0029], lines 16-22; paragraph [0021], lines 5-9.) Finally, when the accumulated fuel is high enough so that the fuel cell unit 3 can provide sufficient electric power, the switch 10 is closed causing the fuel cell to be electrically switched on again. (See paragraph [0021].) This cycle is repeated so that the average power output of the system is reduced avoiding damage to the fuel cell.

One difficulty with the Autenrieth et al arrangement, however, is that the response of the system is relatively slow. That is, when the demand increases sharply, the amount of "pause" time during which the fuel cell system is switched off, becomes relatively longer than during a steady state operation, and recovers only gradually, as fuel accumulates in the anode during the switched off periods, due to the incoming fuel flow.

The present invention builds upon the prior art device, such as disclosed in Autenrieth et al, and provides a system with improved dynamic response. For this purpose, as recited in Claim 1, the <u>quantity of fuel</u> which is supplied to the fuel cell system <u>is adjusted</u> as a function of the "pause-to-switch-on ratio" of the electric connection between the fuel cell and the load. That is, a feedback signal which is indicative of the ratio between the pause interval (during which the system is disconnected), and the switched on interval (during which it is connected), is used to <u>adjust the quantity of fuel</u> supplied to the fuel cell (that is, the flow rate) in a feedback operation, such that the actual value of the pause-to-switch-on ratio converges more quickly to maintain a preset target value. In this manner, the connection between the fuel cell and the load is rapidly restored to an optimal on/off relationship. The latter feature of the invention is also recited in Claim 11, which provides a step of adjusting the rate of fuel flow to the fuel cell system as a function of a feedback signal that is indicative of an open/close ratio of the connection between the fuel cell output and the load.

This feature of the invention is not included in the Autenrieth et al reference, which contains no discussion of controlling, regulating or adjusting the rate at which fuel is provided to the fuel cell unit based on the on/off or "pause-to-switch-on ratio of the electric connection", such that the latter is regulated to a preset value. Rather, as noted previously, Autenrieth et al merely provides that, "While the fuel cell unit 3 is switched off, fuel and/or oxygen <u>is continually supplied</u> until a sufficient quantity of fuel and/or oxygen is available for the fuel cell unit 3 to be able to provide the required electric power". (Paragraph [0021], lines 6-10.) Similarly, at paragraph [0029], lines 19-20 Autenrieth et al states that, "[T]he reformer <u>continues to supply hydrogen</u> causing the pressure to increase again on the anode side. When a desired hydrogen pressure value has been reached, the fuel cell unit 3 can be electrically switched on again." Finally, at paragraph [0030], line 6, Autenrieth et al provides that when the available quantity of fuel drops below a specified first threshold value, "the fuel cell unit is electrically switched off and the battery supplies all require power, <u>while at least the fuel supply to the fuel cell unit 3 continues to be maintained</u>".

In other words, when the power output of the system is switched off (and therefore it consumes no fuel), the fuel simply continues to flow, and because it is not consumed, it accumulates to a point where the power output can be resumed. Autenrieth et al contains no teaching or suggestion regarding varying the rate of fuel flow in response to the on/off or pause-to-switch-on ratio of the electrical connection between the fuel cell and the load.

The present invention (in which the inventor is the same Rainer Autenrieth as in the cited reference) thus constitutes a further development of the system in Autenrieth et al, which improves its reaction time by increasing or decreasing the rate at which fuel flows to the fuel cell as a function of the ratio of the "open" to "close" time of the switch 10 in Autenrieth et al. That is, as discussed, for example, at paragraphs [0026] – [0031], and illustrated in Figure 3, in response to an increase in the proportion of time during which the switch is open ("paused", indicating that the fuel cell is incapable of delivering the required power to the load), "the system responds according to the method described here, by increasing the quantity Q of metered fuel supply 5, as can be recognized in the course 18 of the quantity Q over the time T." (Paragraph [0030], lines 3-4.) In other words, when the P/E ratio (that is, the time during which the load is "paused" versus connected) increases, the system increases the rate at which fuel is provided to the system (that is, the "quantity Q over time"), as shown in the bottom time line of Figure 3, for which the ordinate is labeled "Q". Thus, the system utilizes the "control voltage" referred to in paragraph [0016] of Autenrieth et al, in a negative feedback loop, to regulate the flow of fuel to the fuel cell system. Autenrieth et al contains no disclosure which teaches or suggests such an arrangement.

In response to the observations set forth above, item 8 of the office Action refers to paragraph [0016] of Autenrieth et al, which relates to the ratio (referred to in the present application as P/E ratio) between the open and closed time of

the switch 10 in Figure 2 of Autenrieth et al. Applicants agree with the Examiner's observation that the switch 10 is operated in response to the build up of fuel, as noted, for example, in paragraph [0016], lines 6-17. However, Applicants respectfully submit that neither this nor any other portion of Autenrieth et al teaches or suggests regulating <u>the rate at which fuel is supplied to the fuel cell system as a function of the pause-to-switch-on ratio of the switch 10</u>, or more particularly as a function of a feedback signal that is indicative of such ratio. In this regard, the cited disclosure indicates only that, "While the fuel cell unit 3 is switched off, fuel and/or oxygen is continually supplied until a sufficient quantity of fuel and/or oxygen is available for the fuel cell unit 3 to be able to provide the required electric power". (Paragraph [0021], lines 6-10.) Similarly, at paragraph [0029], lines 19-20, Autenrieth et al states only that, "The reformer continues to supply hydrogen causing the pressure to increase again on the anode side. When a desired hydrogen pressure value has been reached, the fuel cell can be electrically switched on again."

The Continuation Sheet attached to the Advisory Action mailed November 6, 2007 indicates that the response submitted October 29 does not place the application in condition for allowance because, "there is control for a quantity [of fuel] delivered to the fuel cell", due apparently to the opening and closing of the switch 10 in the figure of Autenrieth et al. This conclusion is premised on the proposition that paragraph [0016] of Autenrieth et al mentions that there is a ratio for the open and closed switch, and furthermore that this is

based on the "sufficient burnable gas available" criterion. From these observations, the Advisory Action concludes that "there is control for a quantity delivered to the fuel cell with this control". Applicants respectfully submit, however, that the latter conclusion does not follow from the former premises, and moreover that there is in fact no such control in Autenrieth et al.

The reasoning used to arrive at the conclusion that Autenrieth et al does in fact provide for the type of control recited in the claims of the present application is articulated as follows in the Advisory Action:

> "In the broadest interpretation, the switching on and off switch [1] (open/close ratio) does control the flow. In one instance (the "on" portion), the fuel is flowing. <u>In the other instance (the "off" portion), the fuel is not flowing</u>."

Applicants respectfully submit, however, that the latter statement is incorrect. For example, at paragraph [0021], the specification states that, "While the fuel cell unit 3 is <u>switched off</u>, fuel and/or oxygen <u>is continually supplied</u> until a sufficient quantity of fuel and/or oxygen is available for the fuel cell unit 3 to be able to provide the required electric power." This statement is repeated in paragraph [0022] at lines 2-6. Finally, at paragraph [0029], the specification recites that "Once the pressure [on the hydrogen side of the fuel cell unit 3] drops below a certain value, the fuel cell unit 3 is electrically switched off. <u>However,</u>

the reformer continues to supply hydrogen causing the pressure to increase again on the anode side."

The comment set forth in the Advisory Action focuses on a significant distinction between the present invention and Autenrieth et al. That is, contrary to the stated conclusion in the penultimate paragraph in the Continuation Sheet of the Advisory Action, when the power output of the fuel cell is switched off, it is not true that "the fuel is not flowing". Rather, as described previously, the manner in which Autenrieth et al operates is that the fuel flow continues unabated during the "pause periods", such that, because it is not consumed by the fuel cell itself, it accumulates until the amount of fuel present in the fuel cell is once again sufficient to permit the system output to be switched on. The flow of fuel is neither adjusted nor regulated in this process.

Claim 1 as amended defines a method of controlling the fuel supply to a fuel cell system (of the generic type disclosed in Autenrieth et al), which includes the following steps:

1. generating a feedback signal which is indicative of the pause-to-switch-on ratio between the duration of a pause interval and the duration of a switched on interval of the electric connection between the fuel cell and the consuming device; and

2. adjusting the rate at which fuel is supplied to the fuel cell system as a function of the feedback signal.

Similarly, Claim 11 defines a method of controlling the operation of a fuel cell system which includes the steps of:

1. regulating the power output of the fuel cell system by repeatedly opening and closing a connection between an output of the fuel cell and an electrical load;

2. generating a feedback signal indicative of an open/close ratio for the power output of the fuel cell; and

3. adjusting the rate of fuel flow to the fuel cell system as a function of the feedback signal.

The latter limitations of Claims 1 and 11 are not present in Autenrieth et al, which makes no provision for generating a feedback signal that is indicative of the pause-to-switch-on ratio of the fuel cell power output, or of adjusting the rate at which fuel is supplied to the fuel cell as a function of such a feedback signal. Accordingly, Claims 1 and 11, and therefore all claims of record in this application distinguish over Autenrieth et al for this additional reason as well.

The features discussed above, which distinguish the present invention of Claims 1 and 11 over Autenrieth et al are also neither taught nor suggested by

any of the other references. Higashiyama et al, for example, is cited only as teaching a hydrogen producing apparatus and power generating system which is operated by a flow setting means, such that the average supply flow to a hydrogen generator achieves a desired value.

Similarly, Merritt is cited as teaching a fuel cell with a reactant supply and control system in which the fuel utilization ratio of the reactants is defined as the amount of fuel introduced to the fuel cell per unit time divided by the amount of fuel consumed. It is also cited as teaching optimizing the fuel utilization ratio for limiting reactant to improve fuel cell efficiency.

Finally, Leboe is cited as teaching that the parameter setpoint values within a control scheme may be calculated at discrete intervals and continuously or periodically updated. None of the latter references teaches or suggests controlling the flow rate of fuel into the anode as a function of the on/off or pause-to-switch-on ratio of an electrical connection between the fuel cell and a load, such that the latter is regulated to a present value. Accordingly, Applicants respectfully submit that all claims of record distinguish over such references, or any combination thereof with Autenrieth et al.

In light of the foregoing remarks, this application should be in consideration for allowance, and early passage of this case to issue is respectfully requested. If there are any questions regarding this amendment or the

application in general, a telephone call to the undersigned would be appreciated since this should expedite the prosecution of the application for all concerned.

If necessary to effect a timely response, this paper should be considered as a petition for an Extension of Time sufficient to effect a timely response, and please charge any deficiency in fees or credit any overpayments to Deposit Account No. 05-1323 (Docket #038743.52928US).

Respectfully submitted,

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